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(54) PRODUCTION OF HIGH STRENGTH HOT-DIPPING GALVANIZED STEEL SHEET EXCELLENT IN BENDING WORKABILITY

(57)Abstract:
PURPOSE: To produce a hot-dipping galvanized steel sheet high in tensile strength, contg. a tempered martensitic structure and excellent in bending workability.
CONSTITUTION: This producing method is constituted of a recrystallization annealing stage in which steel contg. 0.05 to 0.3% C, ≤0.6% Si, 0.01 to 0.10% Al, 0.6 to 3.0% Mn and ≤0.1% P, and the balance iron with inevitable impurities is subjected to hot rolling by the conventional method, is thereafter subjected to pickling and cold rolling and subsequently held at the Ac3 point -50°C to 900°C for at least ≥1sec, a galvanizing stage and a stage in which, after the these stages, it is subjected to reheating treatment at the Ac1 point or below to ≥250°C. After the recrystallization annealing stage and before the reheating stage, it is cooled from a temp. higher than the Ms point at least to the Ms point or below at a cooling rate higher than the critical cooling rate CR (°C/s) shown by the following formula: LnCR=-1.18Mneq+1.87 (where Mneq=Mn+1.52Mo+1.10Cr+1.4V+100B).

CLAIMS

[Claim(s)]

[Claim 1]A manufacturing method of a high intensity hot-dip zinc-coated carbon steel sheet excellent in bending nature characterized by comprising the following.
The C:0.05 to 0.3% (hereafter the same) at weight %, Si : 0.6% or less, aluminum: 0.01-0.10%, Mn : 0.6 to 3.0% and P:0.1% or less are contained, A recrystallizing annealing process of including holding steel in which the remainder consists of iron and inevitable impurities at least 1 second or more at Ac_3 point-50 **-900 ** temperature after hot-rolling by a usual method after cold-rolling, pickling and.
A process of galvanizing.
It has the process that below Ac_1 point performs a reheating process at temperature of not less than 250 ** after these processes, after said recrystallizing annealing process -- a following formula from a temperature higher than an Ms point before said reheating process process and LnCR=-1.18Mneq+1.87 -- here, [and] Tempering martensitic structure cooling below to an Ms point at least with a cooling rate more than critical cooling rate CR (**/s) shown by Mneq=Mn+1.52Mo+1.10Cr+1.41V+100B.

[Claim 2]Mo:0.01-1.0%, Cr: A method according to claim 1 which contains 1 of V:0.1-1.5 sorts, and two sorts or more 0.1 to 1.5%.
[Claim 3]Nb:0.01-0.05%, Ti: A method containing 1 of 0.01 to 0.05% of sorts, and two sorts according to claim 1 or 2.
[Claim 4]A method containing further B:30 ppm or less according to claim 1, 2, or 3.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]This invention relates to the manufacturing method of the hot-dip-zincing high intensity steel plate which was excellent in the bending nature in which tensile strength contains the tempering martensitic structure of about 440 - 1500N/mm^2 in more detail about the hot-dip-zincing high intensity steel plate excellent in bending nature.
[0002]
[Description of the Prior Art]In recent years, the high intensity cold rolled sheet steel which was excellent in processability as the safety and the measure against a weight saving against a car has come to be used. Cold rolled sheet steel is strongly expected improvement in rustproof force for the improvement in a life of a car. In these days, the alloying hot-dip zinc-coated carbon steel sheet of high intensity is requested from reinforcing members, such as a bumper for cars, and a door impact beam. The bumper for cars, a door impact beam, etc. are especially complicated also about processing, and bending nature and elongation flange nature are required parts.
[0003]
[Problem(s) to be Solved by the Invention]Although the outstanding bending nature and stretch flanging workability were conventionally demanded of the reinforcing member with high intensity as mentioned above, when it was a hot-dip zinc-coated carbon steel sheet, it was difficult for using tempering martensitic structure to give those characteristics in the continuous processing line of an effective thing.
[0004]In view of the above-mentioned conventional technology, tensile strength is about 440 - 1500N/mm^2, and an object of this invention is to provide the method that the hot-dip zinc-coated carbon steel sheet excellent in the bending nature containing tempering martensitic structure can be manufactured.
[0005]
[Means for Solving the Problem]A result of having repeated research wholeheartedly in order to improve bending nature (lambda value) especially in a continuous processing line where this invention persons include a hot-dip-zincing process in order to solve said SUBJECT, When [in which

it is based on hot-rolling, cold rolling, a recrystallizing annealing process, and a galvanization process] manufacturing, A reheating process was established after a galvanization process, and further, it is after a recrystallizing annealing process, and found out that it was possible by annealing by performing hardening cooled with a predetermined cooling rate before a reheating process, and obtaining martensite, and this invention was completed here.

[0006]This invention Namely, C:0.05 to 0.3%, and less than Si:0.6%. aluminum: 0.01-0.10%, Mn : 0.6 to 3.0% and P:0.1% or less are contained, Further if needed Mo:0.01-1.0%, Cr:0.1-1.5%, 1 of 0.1-1.5 sorts, two sorts or more, or Nb : V: 0.01 to 0.05%, Ti : It contains combining suitably 1 of 0.01 to 0.05% of sorts, two sorts, or B:30 ppm or less, A recrystallizing annealing process of including holding steel in which the remainder consists of iron and inevitable impurities at least 1 second or more at Ac_3 point-50 **-900 ** temperature after hot-rolling by a usual method after cold-rolling, pickling and, It has a process of galvanizing, and the process that below Ac_1 point performs a reheating process at temperature of not less than 250 ** after these processes, after said recrystallizing annealing process -- a following formula from a temperature higher than an Ms point before said reheating process process and LnCR=-1.18Mneq+1.87 -- here, [and] . It is characterized by cooling below to an Ms point at least with a cooling rate more than critical cooling rate CR (**/s) shown by Mneq=Mn+1.52Mo+1.10Cr+1.41V+100B. A manufacturing method of a high intensity hot-dip zinc-coated carbon steel sheet excellent in bending nature which has tempering martensitic structure is made into a gist.

[0007]

[Function]

[0008]This invention is explained still in detail below. The reason for limitation of the chemical entity of steel in this invention is explained first.

[0009]C: It is an element which improves the hardenability of a steel plate, and C makes the volume rate of martensitic structure increase, and contributes also to the intensity of steel greatly, and is the most important element in this invention. That is, in order to secure predetermined intensity and to have bending nature, even if it is necessary to make not less than at least 3% of martensitic structure generate beforehand in process in the manufacturing method of this invention and takes hardenability into consideration for this reason, C must be added at least 0.05% or more. In the case of the addition not more than it, by the manufacturing method of this invention, neither effective martensitic structure nor its volume rate can be secured, and it cannot have the bending nature or stretch flanging workability of high intensity sufficient by a basis. About the maximum of the amount of C, in order to obtain martensitic structure 100%, 0.3% of the amount of C is enough, the addition beyond this reduces ductility by generation of carbide, and weldability is also degraded. Therefore, let the amount of C be 0.05 to 0.3% of range.

[0010]Si:Si is effective as a solid-solution-strengthening element which raises intensity, without degrading ductility. Since it has an effect which eliminates the dissolution C in a ferrite into austenite, there is an operation to which generation of martensite is urged by austenite stabilization. However, Si is an element which degrades plating adhesion when galvanizing, and becomes the cause of not plating, in alloying treatment. For this reason, the amount of Si is made into 0.6% or less.

[0011]Addition [optimum dose Mn:Mn] is a tempering process among the manufacturing processes of this invention, and can make a martensitic phase generate with a comparatively loose cooling rate in the cooling process below an Ms point. However, since a band organization will progress and ductility etc. not only fall, but it will become a high cost if it adds too much, let the amount of Mn be 0.6 to 3.0% of range.

[0012]P: P is effective in order to have the same operation as Si and to secure the balance of intensity and elongation, but since poor plating will occur if it adds more mostly than 0.1%, make the amount of P into 0.1% or less. For acquiring the above-mentioned effect, 0.02% or more is desirable.

[0013]Although it is added for the deoxidation of steel and 0.01% or more of aluminum:aluminum is required for that purpose, since an effect is not only saturated, but poor plating is caused even if it adds too much, it may be 0.1% or less 0.01% or more.

[0014]In this invention, if needed besides each above-mentioned essential ingredient Mo:0.01-1.0%, Cr: 0.1-1.5% and V:0.1 to 1.5% of group, Nb:0.01-0.05%, Ti: At least one sort of elements chosen from 0.01 to 0.05% of group and the group which consists of B:30 ppm or less may be made to contain.

[0015]Mo:Mo stabilizes an austenite phase remarkably, and it is added if needed in order to make generation of a martensitic phase easy in a cooling process. However, if there are few additions, since a martensitic phase cannot be obtained, 0.01% or more needs to be added, but since poor plating will be caused if it adds exceeding 1.5%, let an addition be 0.01 to 1.5% of range.

[0016]Cr, V:Cr, and V are added if needed, in order to have the same effect as Mn, to stabilize an austenite phase and to make generation of a martensitic phase easy. In order to acquire the effect, 0.1% is respectively required at least, but ductility will be reduced if it adds too much. For this reason, let the addition of Cr and V be 0.1 to 1.5% of range respectively.

[0017]Nb, Ti:Nb, and Ti are the elements which combine with C in steel and generate carbide, and do not influence 2nd phase structures, such as martensitic structure. However, it is an element which it may be added since it is an effective element when attaining high intensity-ization by carbide, and can be effectively used in this invention. The range of these ingredients effective in high intensity is 0.01 to 0.05% of range respectively.

[0018]B: B is an element which carries out a segregation to an austenite grain boundary, suppresses the nucleation of a ferrite grain, and improves the hardenability of martensitic structure. Since it will be saturated if this effect exceeds 30 ppm, it may be 30 ppm or less for cost reduction.

[0019]Next, the manufacturing conditions in the method of this invention are explained.

[0020]First, after the steel which has the above-mentioned chemical entity performs hot-rolling, pickling, and cold-rolling by the usual method, let it be a hot-dip zinc-coated carbon steel sheet like a recrystallizing annealing process and a plater.

[0021]Here, recrystallizing annealing is performed on the conditions held at least 1 second or more at Ac_3 point-50 **-900 ** temperature. Soaking temperature does not generate the quantity of austenite texture sufficient at below a minimum, for this reason, the amount of tempering martensitic structure also decreases and required elongation flange nature cannot be obtained. Since the effect will be saturated and an economic burden will become large if it exceeds 900 **, it is not desirable.

[0022]And in order to anneal the organization of a hot-dip zinc-coated carbon steel sheet and to

consider it as a martensitic phase, the organization of steel is first made into a ferrite + austenite phase or austenite single phase at the temperature more than a ferrite + austenite phase. That is, in order to consider it as a ferrite + austenite phase or austenite single phase, it is necessary to hold at least 1 second or more to Ac_3 point-50 **-900 ** temperature.

[0023]then -- up to the temperature below the starting temperature which generates martensitic structure -- a following formula and LnCR=-1.18Mneq+1.87 -- here, By speed cooling more than CR (**/s) of which a Mneq=Mn+1.52Mo+1.10Cr+1.41V+100B definition is done, an austenite phase makes an austenite phase a martensitic phase by burning to the temperature below the Ms point which metamorphoses into a martensitic phase. This Ms point may change with the chemical entities and heat treatment conditions of steel, and may change the temperature of an Ms point using these.

[0024]In this invention, the tempering martensitic structure excellent in bending nature is obtained by below Ac_1 point in which an austenite phase does not carry out regeneration further reheating at the temperature of not less than 250 **. This reheating process may be heat treatment for alloying.

[0025]Although it is not necessary to say, as long as it is after a recrystallizing annealing process, it may perform performing this hardening before a reheating process by any of the order like a plater.

[0026]Also when each process of these heat treatments does not need to say that these processes can be carried out in the hot-dip-zincing line performed continuously and batch annealing performs a reheating process after the process of galvanizing, further, it is possible. Before and after giving continuation hot dip zincing, it may place as a continuous annealing line.

[0027]Next, the example of this invention is shown. Of course, this invention is not restricted at all by this example.

[0028]

[Example]

[0029]The steel which has a chemical entity shown in Table 1 was ingoted, and it was made the slab of 20-mm thickness. This was hot-rolled with the finishing temperature of 850 **, and the coiling temperature of 560 **, and it was considered as the hot rolled sheet steel of 3.2-mm thickness. Pickling of the obtained steel plate was carried out, and it was considered as the cold rolled sheet steel of 1.2-mm thickness with cold rolling. About the obtained cold rolled sheet steel, it heat-treated by three heat patterns shown in drawing 1 - drawing 3. The soaking temperature (Ts) of recrystallizing annealing, the cooling rate (CR) in hardening (the hardening temperature of 600 ** or 750 ** are shown in each figure) and the cooling finishing temperature (Tf), the reheating temperature (To), and its retention time (to) in various thermo cycles are shown in Table 2 and 3. The mechanical properties of the obtained hot-dip zinc-coated carbon steel sheet are also written together.

[0030]

[Table 1]

No.	C	Si	Mn	P	S	Al	Mo	Cr	V	Ti	Nb	B	備考
1	0.02	0.12	2.1	0.008	0.002	0.05	—	—	—	—	—	—	比較鋼
2	0.08	0.10	2.2	0.007	0.001	0.04	—	—	—	—	—	—	本発明鋼
3	0.15	0.11	2.0	0.006	0.002	0.05	—	—	—	—	—	—	〃
4	0.24	0.12	2.1	0.005	〃	0.06	—	—	—	—	—	—	〃
5	0.45	0.11	2.1	0.008	〃	0.05	—	—	—	—	—	—	比較鋼
6	0.25	0.10	2.0	0.007	〃	0.06	0.5	—	—	—	—	—	本発明鋼
7	0.24	0.11	〃	〃	〃	0.05	—	0.5	—	—	—	—	〃
8	0.25	0.10	2.1	0.008	〃	0.06	—	—	0.5	—	—	—	〃
9	0.26	0.09	2.2	0.007	〃	0.05	—	—	—	0.03	—	—	〃
10	0.24	0.10	〃	〃	〃	〃	—	—	—	—	0.03	—	〃
11	0.23	0.12	2.1	0.008	〃	0.04	—	—	—	—	—	0.002	〃
12	0.15	0.2	2.0	0.08	〃	0.05	—	—	—	—	—	—	〃
13	0.14	0.4	2.1	〃	〃	0.04	—	—	—	—	—	—	〃
14	0.15	0.5	2.0	〃	0.001	0.04	—	—	—	—	—	—	〃
15	0.14	0.02	〃	0.07	〃	0.05	—	—	—	—	—	—	〃
16	0.15	0.1	0.8	〃	0.002	〃	—	—	—	—	—	—	〃
17	0.14	〃	1.5	0.08	〃	〃	—	—	—	—	—	—	〃
18	〃	〃	2.5	〃	〃	0.06	—	—	—	—	—	—	〃
19	0.15	0.1	2.0	0.05	〃	0.05	—	—	—	—	—	—	〃
20	0.14	〃	〃	0.03	〃	0.06	—	—	—	—	—	—	〃
21	〃	〃	〃	0.01	〃	0.04	—	—	—	—	—	—	〃

[0031]
[Table 2]

試験No.	鋼種No.	Ts (℃)	均熱時間 (s)	Tf (℃)	To (℃)	OA時間 to(s)	TS (N/mm²)	El (%)	λ (%)	ヒートパターン	区分
1	1	820	15	500	550	15	450	35	75	I	比較例
2	1	〃	〃	200	〃	〃	453	37	68	〃	〃
3	2	〃	〃	500	〃	〃	600	29	44	〃	〃
4	2	〃	〃	200	〃	〃	〃	28	54	〃	本発明例
5	3	〃	〃	500	〃	〃	760	23	27	〃	比較例
6	3	〃	〃	200	〃	〃	800	18	50	〃	本発明例
7	4	〃	〃	500	〃	〃	1000	13	13	〃	比較例
8	4	〃	〃	400	〃	〃	1200	12	10	〃	〃
9	4	〃	〃	380	〃	〃	1170	13	16	〃	〃
10	4	〃	〃	300	〃	〃	1025	12	38	〃	本発明例
11	4	〃	〃	180	〃	〃	1175	11	32	〃	〃
12	4	〃	〃	100	〃	〃	1200	13	35	〃	〃
13	5	〃	〃	200	〃	〃	1027	14	18	〃	比較例
14	6	〃	〃	〃	〃	〃	1121	12	38	〃	本発明例
15	7	〃	〃	〃	〃	〃	1192	13	39	〃	〃
16	8	〃	〃	〃	〃	〃	1208	11	40	〃	〃
17	9	〃	〃	〃	〃	〃	1210	10	35	〃	〃
18	10	〃	〃	〃	〃	〃	1195	12	37	〃	〃
19	11	〃	〃	〃	〃	〃	1183	13	35	〃	〃
20	4	840	〃	〃	〃	〃	1300	8	35	〃	〃

[0032]Heat pattern (I) is a pattern like a recrystallizing annealing process, a tempering process, and a plater which performs a reheating process continuously.
It is a pattern which heat pattern (II) performs continuously a recrystallizing annealing process, plating, and a tempering process, and makes a reheating process a batch process, and heat pattern (III) is a pattern which performs a recrystallizing annealing process and a tempering process continuously, and carries out a reheating process like a plater with a batch process.

[0033]lambda value in Table 2 and 3 is a value which shows bending nature, and the hole expanding

test which extends this hole until it pierces the hole of 10 mmphi beforehand and a crack arises to the circumference of a hole to the cone punch at 60 degrees of tips, as shown in drawing 4 estimated that test method at a rate (rate of hole expanding) of that spread. the rate lambda of hole expanding -- lambda={(d_0-ds) /d_0} x100 (%) -- (-- it asked by the formula of d_0:initial bore-diameter [of 10 mm] phi) here.

[0034]It is considered as the following from Table 2 and 3.

[0035]Comparative example No.1 - No.2 are examples with few amounts of C, since there are few amounts of martensite, it is almost ineffective, and especially lambda value is low.

[0036]No.3-No.4, No.5-No.6 and No.7 - No.12 are the examples to which cooling finishing temperature (Tf) was changed to about 500-100 ** about steel type No.2, No.3, and No.4, respectively. The Ms point in this case has every steel type in the 350 ** range of **30 **, and, in the case of cooling finishing temperature (Tf) higher than this temperature (comparative example No.3, No.5, No.7-No.9), good lambda value is not accepted.

[0037]No.13 - No.19 are the examples which heat-treated on condition of this invention within the limits about steel type No.5 (outside of this invention range), and No.6-No.11.
About steel types other than steel type No.5, it turns out that it has good bending nature.

[0038]No.20 - No.24 are the examples to which the soaking temperature (Ts) of recrystallizing annealing was changed, and, in the case of soaking temperature (less than [Ac_3 point-50 **]) besides this invention generic claim (No.24), good bending nature is not obtained.

[0039]No.25-No.28 and No.29 - No.30 are the examples in the case of the heat pattern II shown in drawing 1, respectively, and the heat pattern III.
It has good bending nature like the case of the heat pattern I.

[0040]No.31 - No.40 are the examples which applied the heat pattern I to steel type No.12-No.21.
All have good bending nature.

[0041]The influence of cooling finishing temperature (Tf) which it has on lambda value about TS1000 - 1200N / mm^2 class steel type was shown in drawing 5 in the example of Table 2 and 3. The Ms point of this steel type is 350 **, and when it cools to a temperature lower than this, improvement in lambda value is accepted. TS-El and TS-lambda balance of this invention steel about 1200N / TS600N/mm^2 - mm^2 class steel and comparison steel were similarly shown in drawing 6. The effect of the improvement in lambda value was more notably accepted from more than the about 600Ns / the mm^2 class.

[0042]

[Effect of the Invention]As explained in full detail above, in this invention, the hot-dip zinc-coated carbon steel sheet tensile strength excelled [hot-dip zinc-coated carbon steel sheet] in about 440 - 1500N/mm^2 at the bending nature containing tempering martensitic structure can be manufactured. Therefore, it is especially suitable for manufacture of the charge of automobile material.